

## New aspects in the hot injection synthesis to provide large scale high quality quantum dots

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Quantum dots (QDs) exhibit a range of unique optical and (opto-)electrochemical properties and thus are the subject of many research areas including chemistry, physics and material science. Amongst the applications that they may conceivably be used for are: solar cells, light emitting diodes, thermoelectric materials beside others. Such applications require high quality materials with well defined properties, and in particular for industrial implementation, large amounts. The hot injection method is a laboratory based, organo-metallic synthesis approach for the production of high quality colloidal QDs which demands up-scaling of the optimized lab scale synthesis protocols if an industrial scale is required. The synthetic route of the hot injection method involves a rapid injection of a precursor solution into a hot solution of high boiling coordinating components to affect a homogeneous nucleation event which is followed by subsequent growth at lower temperatures.<sup>1</sup> The precursor injection leads to monomer formation and, due to supersaturation, nuclei are formed. After lowering the reaction temperature the energy barrier for nucleation cannot further be overcome and the growth process is favored while nucleation is suppressed. Up-scaling of the precise laboratory scaled reaction conditions is a complex procedure which involves implementing changes to many parameters including those of process engineering as well as physical and chemical values.

In this contribution we present a novel way to optimize the parameters that allow the up-scaled syntheses of high quality CdSe and PbSe QDs. With a modified hot injection procedure, the seeded growth method, nuclei are introduced into the reaction and thus heterogeneous nucleation results. A special case of this approach is the *quasi* seeded growth, wherein nuclei of a different material are formed *in situ* and subsequently a cation exchange occurs whereupon the required seeds are formed and the overall process is simplified to the growth of the particles (see Figure 1).<sup>2</sup> Whilst in the bulk the exchange reaction is kinetically hindered, in the nanoparticulate size regime it is thermodynamically favored.<sup>3</sup> A particular feature of the materials resulting from the up-scaled synthesis is the narrowness of the full width at half maxima of the interband transition peaks as determined by optical spectroscopy of the colloidal solutions and which is a reflection of the quality of the QDs, especially that of the particle size distribution (see Figure 2). It is envisioned that this methodology may be applied to up-scaling the synthesis of other QD materials.

## References

- [1] J. Park *et al.*, *Angew. Chem. Int. Ed.* **46** (2007) 4630.  
[2] M. V. Kovalenko *et al.*, *Angew. Chem. Int. Ed.* **47** (2008) 3029-3033.  
[3] D. H. Son *et al.*, *Science* **306** (2004) 1009.

## Figures

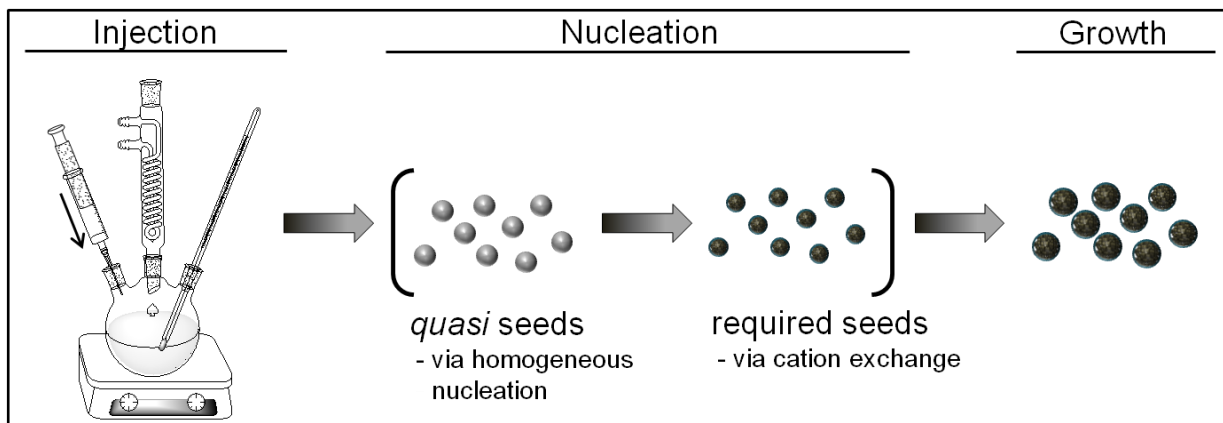


Figure 1: Mechanism of the quasi seeded growth approach.<sup>2</sup>

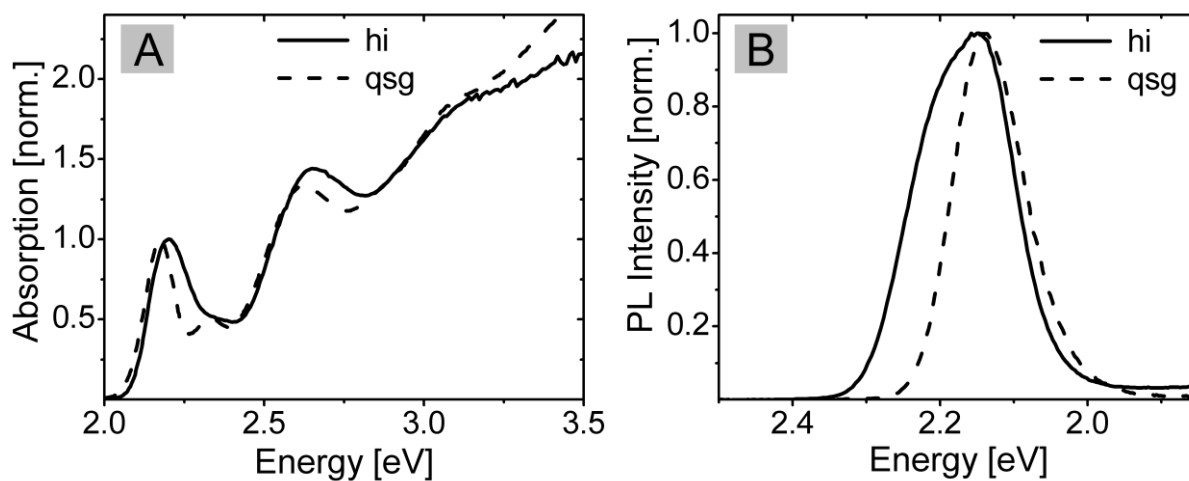


Figure 2: Normalized absorption (A) and emission (B) spectra of the up-scaled approach to provide CdSe nanocrystals via the standard hot injection (hi) as well as the quasi seeded growth method (qsg).